Docket No.: 101328-0151

(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Theodore H. Fedynyshyn

Application No.: 09/851,952

Group Art Unit: 1752

Filed: May 9, 2001

Examiner: Walke, Amanda C.

For: RESIST WITH REDUCED LINE EDGE ROUGHNESS

DECLARATION OF THEODORE H. FEDYNYSHYN
PURSUANT TO 37 C.F.R. 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

I, Dr. Theodore H. Fedynyshyn, a citizen of the United States residing at 32 Atkinson Lane, Sudbury, MA 01776, declare as follows:

1. I received a Ph.D. degree in Chemistry from Brown University in June 1980.

2. I have been employed as a senior scientist at Massachusetts Institute of Technology (MIT) Lincoln Laboratory at 244 Wood Street, Lexington, MA 02420 since October 1997. My responsibilities include conducting and supervising research in the area of resist chemistry, and in particular, in the area of novel resists suitable for use in high energy microlithography.

3. I am the inventor of the invention disclosed in the pending United States Patent Application No. 09/851,952 entitled "Resist With Reduced Line Edge Roughness," which was filed on May 9, 2001. I am familiar with the application and the prosecution conducted to date. In particular, I have studied a final Office Action issued on August 11, 2004 in this application.

4. It is my understanding that a number of claims in the patent application are rejected based on U.S. Patent No. 6,306,554 of Barclay and U.S. Patent No. 5,879,856 of Thackeray because the Examiner purports that a base to PAG molar ratio of 0.1 to 20 and 0.0212 to 0.42 can be inferred from Barclay and Thackeray, respectively.

5. I have performed experiments on photoresist compositions with a base to PAG molar ratios in a range of about 0.8 to about 1.5 to determine viability, and performance characteristics, of such compositions for use as positive photoresists, as described in more detail below.

6. The following resist compositions were prepared by employing a copolymer of p-hydroxystyrene and t-butyl acrylate with a monomer ratio of 60% p-hydroxystyrene and 40% t-butyl acetate as a resist polymer, di-t-butylphenyl iodonium camphor sulfonate (TBPI-CS) as a photoacid generator (PAG), and tetrabutyl ammonium hydroxide (TBAH) as a base.

7. A number of resists, described in Tables 1 below, were prepared by adding the resist polymer, the photo-acid generator (PAG) and the base in the amounts (in parts) listed below to 2757 parts of ethyl lactate solvent to generate a solution. The solution was rolled over night and filtered through a 0.2 micron filter.

Table 1.

Resist	Amount	Polymer	Amount	PAG	Amount	Base	Ratio B/P (molar)
99181	94	60:40	6	TBPI-CS	2.00	TBAH	0.8
99182	94	60:40	6	TBPI-CS	2.25	TBAH	0.9
99183	94	60:40	6	TBPI-CS	2.50	TBAH	1.0
99184	94	60:40	6	TBPI-CS	2.75	TBAH	1.1
99185	94	60:40	6	TBPI-CS	3.00	TBAH	1.2
99186	94	60:40	6	TBPI-CS	3.25	TBAH	1.3
99187	94	60:40	6	TBPI-CS	3.50	TBAH	1.4
99188	94	60:40	6	TBPI-CS	3.75	TBAH	1.5

8. The resists were spin cast to an approximately 55 nm film on a HMDS vapor primed silicon wafer followed by a post apply bake (PAB) at about 140°C for approximately 60. Development was accomplished by utilizing Shipley LLD-26W commercial resist developer. Each resist was exposed to 157 nm radiation at a series of different radiation doses ranging from 0 to 50 mJ/cm^2. After exposure, the wafer was PEB baked at about 130°C for approximately 90 seconds. The wafer was then immersed in a surfactant containing 2.38% aqueous solution of tetramethyl ammonium hydroxide for about 15 seconds. The wafer was then removed, rinsed with DI water, and dried under a stream of nitrogen gas.

9. Table 2 below presents data corresponding to clearing dose (E_0), contrast (γ), unexposed film thickness loss (UFTL), pre-development resist thickness, and post-development resist thickness, for the resists listed in Table 1 above. The clearing dose (E_0), defined as the lowest exposure dose required to remove all resist after development, was determined by either fitting a line through all points containing less than 80% normalized film thickness as a function of exposure dose and determining the intercept for the remaining film thickness to be zero, or if no slope could be determined, by noting the lowest exposure dose for which no resist remained. The contrast (γ) was determined by fitting a line through all points containing less than 80% normalized film thickness as a function of the log of dose and determining the absolute value of the slope. Further, the unexposed film thickness loss (UFTL) was determined by subtracting the film thickness of an unexposed portion of the resist after development from the film thickness of the resist prior to exposure.

Table 2

Resist	E0 (mJ/cm^2)	Contrast (γ)	UFTL (nm)	Pre-development Resist Thickness (nm)	Post-development Resist Thickness (nm)
99181	1.7	15.6	8.7	58.3	49.6
99182	2.3	15.9	8.8	57.7	48.9
99183	>50	NA	8.8	58.8	50.0
99184	>50	NA	8.3	57.8	49.5
99185	>50	NA	9.4	56.0	46.6
99186	>50	NA	9.6	56.0	46.4
99187	>50	NA	9.9	56.8	46.9
99188	>50	NA	10.5	56.2	45.7

10. The experimental data presented above in Table 2 shows that the two compositions having base to PAG molar ratios of 0.8 and 0.9 exhibit sufficient sensitivity, a high enough contrast, and an acceptable UFTL to be employed as 157 nm sensitive photoresists.

11. The experimental data presented above in Table 2 also indicates that the tested resist compositions with base to PAG ratios in a range of 1 to 1.5 require a clearing dose (E_0) greater than 50 mJ/cm^2. In other words, even at the very high exposure dose of 50 mJ/cm^2, some resist film remained on the wafer at the exposed area. Hence, these compositions are not capable of functioning as viable positive photoresists at 157 nm at lithographically useful sensitivities.

I further declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

December 10, 2004 By: Theodore H. Fedynyshyn
Theodore H. Fedynyshyn

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